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RESEARCH AND DEVELOPMENT IN CANADA

Odette Madore
ECONOMICS DIVISION

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RESEARCH AND DEVELOPMENT IN CANADA

INTRODUCTION

Innovation is the foundation for growth, productivity and competitiveness in any economy; it is a process that begins with the discovery of knowledge and ends with its application (industrial or otherwise). This process leads to improved products and production methods or to new products and procedures. Research and development (R&D) resources are only one element in the process of technological innovation and, therefore, represent only a portion of the effort required. However, since R&D activities are at the heart of innovation, R&D statistics are used widely as indicators of its extent.

In Canada, governments, industry and universities carry out most R&D activities. Universities primarily perform basic research, which is aimed at increasing scientific and technical information and discovering new applications for current knowledge. Industry is more concerned with applied research in order to maintain and increase competitiveness. Finally, in addition to conducting research activities in its departments and laboratories, the government tries to promote and direct R&D activities through various programs and measures.

It is not always easy to evaluate precisely the financial resources mobilized through government efforts to promote innovation. Aside from the fact that gaining access to reliable sources is difficult, some forms of assistance also indirectly encourage or contribute to activities other than innovation. In spite of this, it may be useful, in order to put them into perspective, to define the financial aspects of the main types of intervention of the past few years involving the transfer or allocation of funds for R&D.

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In order to provide a more detailed evaluation, we will distinguish between the government's financial commitment in its own laboratories (intra-mural research) and in other sectors, such as industry or universities, carrying out R&D (extra-mural research). Industry and university R&D activities will also be evaluated in order to demonstrate the effect of government innovation policies. We will then comment on federal government intervention. But first, an overview of the research and development situation in Canada will illustrate the relative importance of the federal government, industry and universities in this field.

GROSS DOMESTIC EXPENDITURES ON RESEARCH AND DEVELOPMENT

The total expenditures for R&D in a country in one year correspond to the gross domestic expenditures on research and development (GERD). The OECD defines GERD as follows:

> GERD is the total intra-mural expenditures related to R&D projects carried out within a country over a given period. It includes R&D funded by foreign interests and carried out within the particular country, but does not include payment for R&D projects carried out abroad. GERD is obtained by totalling the intra-mural expenditures of all sectors participating in R&D activities.(1)

GERD in Canada in 1988 was estimated at just under $8 billion. It has more than doubled in nine years and has an average annual growth of approximately 12%. As Graph 1 illustrates, real growth was much lower, averaging 6% for the same period. However, this trend has not been regular. Growth was strong until 1985 but then shifted downward. According to preliminary data from Statistics Canada, the GERB increased by 4.4% between 1987 and 1988.

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(1) OECD, The Measurement of Scientific and Technical Activities, 1981, p. 25.

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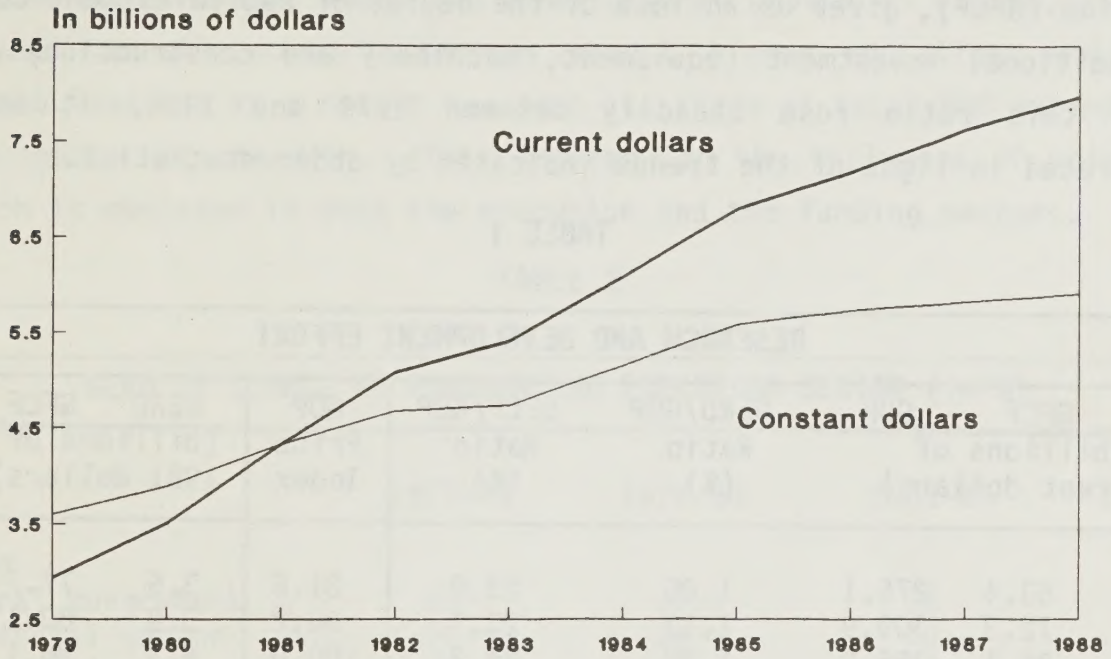
GRAPH 1
GROSS DOMESTIC EXPENDITURES ON RESEARCH AND DEVELOPMENT IN CANADA



Source: See Table A.1 in the Appendix.

Statistics showing the absolute amounts allocated to R&D have the advantage of providing a clear picture of the current situation. However, it is also interesting to turn to indicators that put these figures into perspective by reflecting the effort made in relation to the size of the national economy. One of the more commonly used indicators is the GERD, which is expressed as a percentage of the gross domestic product (GDP).

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Since 1980, the percentage of the GDP allocated to R&D has almost always increased, although it has declined slightly since 1986 (see Table 1). The increase, before 1986 that is, may be interpreted as a genuine effort to promote R&D, given the economic growth (the GDP price index, set at 100 in 1981, has risen steadily and reached 131 in 1987).

Another indicator, the GERD ratio to the gross fixed capital formation (GFCF), gives us an idea of the degree of R&D investment compared to traditional investment (equipment, machinery and construction). Even though this ratio rose steadily between 1979 and 1985, it must be interpreted in light of the trends indicated by other statistics.

TABLE 1

RESEARCH AND DEVELOPMENT EFFORT

	GERD	GFCF	GDP	GERD/GDP Ratio	GFCF/GDP Ratio	GDP Price Index	GERD	GFCF	GERD/GFCF Ratio
	(billions of current dollars)			(%)	(%)		(billions of 1981 dollars)		(%)
1979	2.9	63.4	276.1	1.06	23.0	81.6	3.6	77.7	4.6
1980	3.5	72.3	309.9	1.13	23.3	90.2	3.9	80.1	4.8
1981	4.3	86.1	356.0	1.22	24.2	100.0	4.3	86.1	5.0
1982	5.1	81.3	374.4	1.36	21.7	108.7	4.7	74.8	6.3
1983	5.4	81.2	405.7	1.33	20.0	114.1	4.7	71.2	6.7
1984	6.1	84.7	445.6	1.37	19.0	118.0	5.2	71.8	7.2
1985	6.8	94.2	479.4	1.42	19.7	121.7	5.6	77.4	7.2
1986	7.2	101.3	509.9	1.41	19.9	125.3	5.7	80.8	7.1
1987	7.6	114.4	553.9	1.38	20.7	131.0	5.8	87.3	6.6
1988[1]	7.9	-	-	-	-	134.9	5.9	-	-

1. Preliminary Data

Source: Statistics Canada

According to Table 1, approximately 21% of the GDP consisted of traditional investments in 1987, compared to 24% in 1981. This decrease can, in part, be attributed to the GDP's accelerated growth. Between 1981 and 1984, with the recession at the start of this period taken into account, the percentage of the GDP allotted to traditional investments

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dropped. It recovered somewhat, but by 1986 it still had not reached its 1981 level, which could mean that the equipment used by Canadian industries has become worn and is not being replaced with the latest technology.

The GERD is usually given for two sectors - funding and execution - so that the structure and organization of R&D activities as well as the circulation of funds between sectors are better understood. Since the early 1980s, there has been general growth in Canada, and this has benefited all economic sectors except higher education, which has benefited less and as a result has seen its share of total R&D expenditures drop slightly but steadily. This decrease in the influence of university research is observed in both the execution and the funding sectors.

TABLE 2

GERD BY SOURCE OF FUNDING AND EXECUTION SECTOR (in %)

Sector	1971-75	1976-80	1981-85	1986-88
Funding				
Federal government	43	37	36	32
Industrial sector	29	34	40	42
Universities	15	15	10	10
Execution				
Federal government	29	25	22	18
Industrial sector	35	40	49	54
Universities	31	30	24	23

Source: Statistics Canada

The change in the funding of R&D activities by the federal government and industry is the most striking feature of the past two decades (see Table 2). These two funding sources still provide most of the resources in the GERD, but, since 1980, industry has replaced the federal government as the main source of funds. The figures on execution by the federal government are down as well.

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FEDERAL RESEARCH AND DEVELOPMENT

According to preliminary data from Statistics Canada, the federal government will have spent $2.7 billion on R&D activities in 1988-89, 4% more than the year before. Even though federal R&D expenditures have clearly increased over the past eight years, the increase is not as large when inflation is taken into account. The budget cuts that began in 1984 have reduced federal R&D expenditures. The consistently smaller increases, evident since 1986, can be explained in part by the new federal fiscal plan set forth on 26 February 1986, which projected a slower rate of growth in spending in all areas (see Table A.3 in the Appendix).

The amount that the federal government budgeted for R&D activities (see Graph 2) was greater in 1987-88 (2.1%) than seven years earlier (1.9%). According to these figures, the government has given R&D a relatively important position given that, until 1985, expenditures in this area were increasing more rapidly than in other areas. Recently, however, increases in R&D expenditures have been smaller than increases in total government spending. According to Table A.3 in the Appendix, R&D funds are distributed among a small number of departments. In fact, Agriculture Canada and the National Research Council together fund over half of all R&D activities.

Natural sciences and engineering activities receive the largest share of federal government funding (95% in 1988-89). The government places a particular emphasis on industry support, advancement of science, agriculture and defence (see Appendix, Table A.4).

Industry support is expected to rank first in 1988-89 with approximately 20% of all public funding for R&D activities. One of the main reasons for giving industrial programs such priority is the 1987 policy change towards favouring industry. This priority also reflects the move to integrate sciences with technology and industry, which was achieved in 1989 with the creation of Industry, Science and Technology Canada.

For the first time since the early 1980s, the advancement of science (basic research), was the second most important R&D policy goal in 1988-89. It is expected it will have received 15% of public R&D funding,

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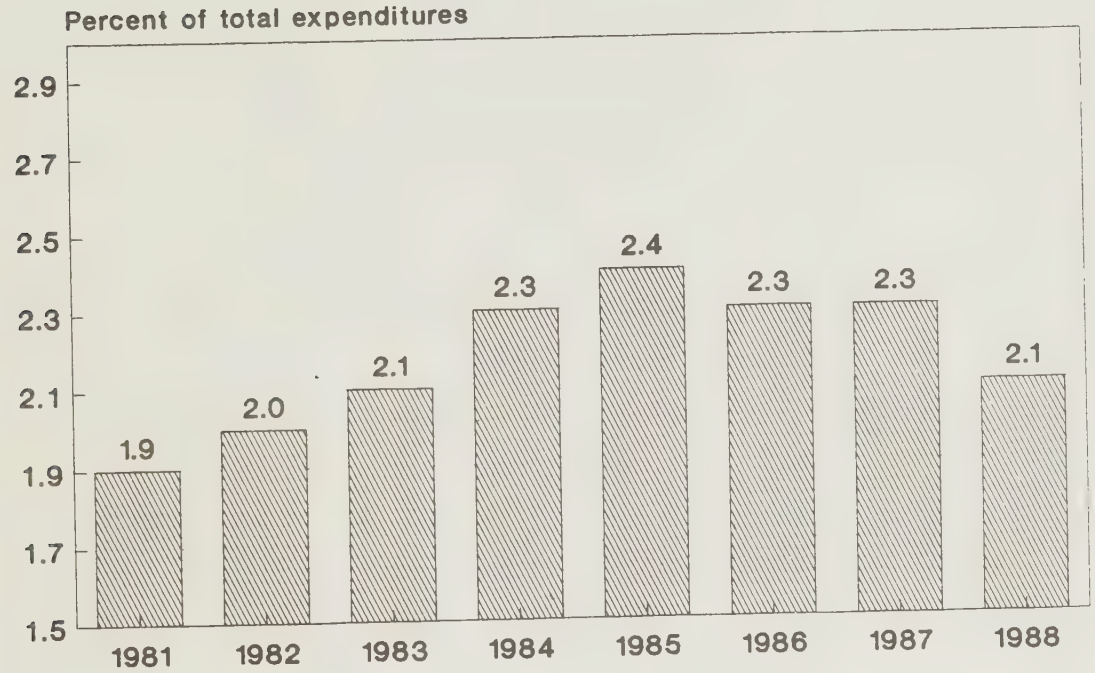
GRAPH 2
FEDERAL EXPENDITURES ON R&D AS A PERCENT OF TOTAL FEDERAL SPENDING



Source : Statistics Canada.

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approximately the same percentage as in previous years. Agriculture is expected to have received 12% of public funding, the same amount as in 1987. The amount allocated to defence generally increases from year to year. It therefore appears that federal R&D policy increasingly favours socio-economic objectives rather than general, non-specific work. In the area of R&D in energy, there was an overall decline; expenditures are expected to have decreased noticeably in 1988-89, representing only 7% of all federal R&D spending.

The federal government allocates some of its R&D funds to work carried out in its own scientific institutions (intra-mural research). The distribution of these funds is shown in the Appendix, Table A.5. The government will have carried out 48% of the R&D work that it funded in 1988-89, down from 54% in 1987-88 and 56% in 1980-81. Thus, the federal government is allocating more and more R&D funds to non-governmental organizations (extra-mural research), especially to industry.

There is some opposition to this. The Professional Institute of the Public Service of Canada has expressed reservations about the increasing amount of attention paid to industrial R&D. In a 1988 report, PIPS pointed out that real funding for federal laboratories has decreased continuously over the last decade and that:

> a large percentage of internal government expenditures goes towards the salaries and benefits of the research staff, with the balance covering basic research needs. For example, the budget for some agricultural research stations is less than $1,000 for each scientist's research costs for the entire year! These funds clearly cannot maintain specialized research facilities.(2)

It is difficult to determine the most effective distribution of funds for intra-mural and extra-mural research. Nevertheless, the government is still concerned with the private sector's weak showing in research, as is clearly reflected by the objective of its 1980s innovation policy.

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(2) Professional Institute of the Public Service of Canada, The Essential Role of Federal Scientists and Engineers: Their Role in the National Economy, 1988, p. 7.

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As in the past, universities and industry are expected to have received most of the extra-mural funding in 1988-89, at 45% and 46% respectively. However, since the early 1980s, there has been a marked redirection of federal R&D extra-mural funds to industry. In 1980-81, 36% was allocated to industry, while 47% was allocated to higher education.

Although the quality of federal intra-mural research is recognized, two problems reduce the benefits to industrial development. First, it is asked whether federal intra-mural R&D meets the needs of industry. Second, according to Boismenu and Ducatenzeiler,(3) research results are not always disseminated adequately between the two sectors.

FEDERAL SPENDING IN INDUSTRY

In 1988-89, the federal government is expected to have increased by 30% the amount given to commercial enterprises, to a total of $621.8 million (Table A.6 in Appendix). This amount has doubled between 1982-83 and 1987-88, with real growth of 26%. The Department of Regional Industrial Expansion is the biggest source of industrial R&D funds (41%) with the Department of National Defence and the National Research Council placing second (18% each).

The federal government funds R&D activities in the industrial sector in three ways: grants and contributions, contracts, and tax measures (see Table 3).

(3) G. Boismenu and G. Ducatenzeiler, Les subventions fédérales à l'innovation industrielle, GRETSE, Montreal, 1986, p. 22-23.

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TABLE 3

FEDERAL R&D EXPENDITURES IN THE INDUSTRIAL SECTOR BY TYPE OF PAYMENT
(in millions of dollars)

	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88[1]	1988-89[1]
Grants	168.4	220.9	251.6	280.2	280.5	260.1	388.8
Contracts	151.0	158.9	170.1	187.6	199.3	220.2	233.0
TOTAL	319.4	379.8	421.7	467.8	479.8	480.3	621.8

1. Preliminary Data

Source: Statistics Canada

A grant is an unconditional payment that the government makes to a recipient who meets certain eligibility requirements but who does not necessarily have to respond with direct services. It has the economic advantage of encouraging the company to increase its own investment activity. According to a study by A. Tarasofsky,(4) it seems that federal grants tend, on average, either to encourage increased spending by the recipient firm or leave it unchanged.

Contracts encourage Canadian industry to participate in federal programs. Under contract agreements, the government determines the nature and general objective of the R&D activity to be carried out. Contracting out to the private sector enables the government to meet its equipment needs. The federal government's public contracting policy, which is first and foremost a purchasing policy, enables the various departments to be supplied by industries with leading-edge equipment and therefore promotes technological innovation.

(4) A. Tarasofsky, The Subsidization of Innovation Projects by the Government of Canada, Economic Council of Canada, 1984, p. 14.

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In short, direct assistance such as grants and, to a lesser extent, contracts leaves the technological development initiative to business. However, payments for R&D programs seem to be concentrated in certain industries. Table A.7 in the Appendix illustrates that the federal government mainly gives support to the following sectors: aircraft and parts ($125 million), other electronic equipment ($63 million) and engineering and scientific firms ($60 million).

The federal government also offers measures to stimulate the development of high technology. Between 1977 and 1985, the federal investment tax credit allowed companies to claim 10% to 25% of their R&D expenditures. Since November 1985, this percentage has varied between 25% and 35%, depending on the size of the company and where the R&D work is carried out.

Although this credit reduces the total amount of tax which would otherwise be payable, it must be added in the calculation of taxable income, just like an equipment grant. Therefore, the effect of the investment tax credit is diminished by the corporate tax rate. However, tax reform will suppress or limit some measures included in the investment tax credit.

INDUSTRY RESEARCH AND DEVELOPMENT

It is expected that the commercial sector will have carried out approximately 55% of all R&D in Canada in 1988, which would make it the main executing sector. Industrial R&D expenditures, shown in Table 4, have increased regularly since 1979 and increased 250% between 1979 and 1988. However, the real growth is much lower than this figure. When the GDP price index is used to take inflation into account, the increase is only 112%. Industrial R&D expenditures are expected to have attained their highest level in 1988, close to $4.5 billion.

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In spite of the healthy increase in spending in this field, R&D is generally still considered a secondary activity by Canadian industry. Most companies carry out no research at all; therefore, most industrial R&D in Canada is carried out by a small number of companies. Of the 3,414 companies that reported carrying out R&D in 1986, 25, or 1%, accounted for almost half of the R&D activity. Only 13 companies spent more than $50 million; 21 companies spent more than $25 million and 105 companies spent more than $5 million.

TABLE 4

R&D EXPENDITURES IN THE INDUSTRIAL SECTOR
(in millions of dollars)

	Current Dollars	Constant Dollars
1979	1,266	1,551
1980	1,571	1,742
1981	2,125	2,125
1982	2,489	2,289
1983	2,585	2,265
1984	2,994	2,537
1985	3,619	2,974
1986	3,838	3,055
1987	4,158	3,174
1988[1]	4,427	3,282

1. Preliminary Data

Source: Statistics Canada

Because of this, R&D expenditures are also concentrated in certain areas of activity. Six main industries - telecommunications equipment, aircraft and parts, engineering and scientific firms, office machines, computer services, refined petroleum and coal products and other chemical products - account for 50% of all intra-mural R&D spending. It should be remembered that the federal government gives two of these industries most of the extra-mural funding. Over the past few years, these industries have maintained their domination of industrial R&D. The

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telecommunications equipment industry alone accounts for 19% of all industrial intra-mural spending.

According to the statistics in Table 5, the distribution of industrial R&D funding sources has not changed greatly during the 1980s. The major source is still executing companies, which financed 65% of their own R&D activities in 1988, compared with 75% in 1980. Table A.7 in the Appendix illustrates that the proportion of self-funding a business may range from 19% to 99% depending on the industry.

TABLE 5

FUNDING SOURCES FOR INDUSTRIAL R&D
(in millions of dollars)

	Canadian Executing Company	Federal Government	Provincial Governments	Other Canadian Sources	Foreign Sources	Total
1980	1,185	119	23	153	91	1,571
1981	1,548	190	37	196	153	2,125
1982	1,706	266	44	215	258	2,489
1983	1,612	281	40	236	416	2,585
1984	1,817	336	43	290	508	2,994
1985	2,347	383	50	357	482	3,619
1986	2,464	409	54	386	515	3,828
1987	2,712	418	48	421	559	4,158
1988[1]	2,887	445	51	449	595	4,427

1. Preliminary Data

Source: Statistics Canada

The second major Canadian source is the federal government with 11%; this figure has not changed since 1982. As seen in Table A.7, federal contributions vary greatly depending on the industry: 19% of funding for engineering and scientific firms comes from the federal government, whereas the drugs and medication industry receives only 2%. The effect of these tax concessions on the public treasury is not included in these figures.

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The importance of foreign funding sources for industrial R&D in Canada should not be overlooked. The large number of foreign firms in the manufacturing sector carried out 6% to 17% of the industrial research activities in Canada between 1980 and 1988.

In a Conference Board of Canada(5) survey that asked companies what would affect their investing in R&D in 1989, 43.5% of the respondents stated that they believed federal policies could do so adversely. Some companies expressed disappointment with the federal government's current policy on technology; others were wary of tax reforms affecting R&D activities; still others said that the federal government was not putting enough emphasis on R&D. This partly explains why, according to the survey, the rate of increase for industrial R&D expenditures was expected to drop to 4.1% in 1989, down from 7.8% in 1988. It should be remembered that company decisions on R&D are also influenced by the government's defence, transport and communications policies, by national and international economic trends and by the financial situation of the companies themselves.

FEDERAL SPENDING IN THE UNIVERSITY SECTOR

The federal government plays a relatively minor role in university research. Of $1.7 billion in research funds given to Canadian universities in 1987-88, $539 million came from the federal government. Federal contributions are channelled through three funding agencies; the Natural Sciences and Engineering Research Council (NSERC), the Medical Research Council (MRC) and the Social Sciences and Humanities Research Council (SSHRC). The NSERC by far distributes most of the money to universities. Even though federal contributions to university R&D increase year after year (except for the 1985-86 fiscal year), their share of total R&D expenditures has remained about the same at 21% annually on average (see Table 6).

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(5) J. Warda, R and D Outlook 1989 - Research and Development in the Canadian Corporate Sector, Conference Board of Canada, 1988, p. 2-3.

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TABLE 6

FEDERAL R&D EXPENDITURES IN THE UNIVERSITY SECTOR
(in millions of dollars)

	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88
Grants						
Medical Research Council	98.1	122.6	137.4	140.9	145.6	48.6
Health and Welfare Canada	8.0	8.0	8.2	8.3	9.1	8.8
National Research Council	21.2	23.2	25.6	26.7	26.1	24.1
National Sciences and Engineering Research Council	199.8	227.0	245.8	243.3	246.0	55.3
Social Sciences and Humanities Research Council	28.3	30.4	32.2	28.8	30.9	30.8
Others	10.7	9.7	20.5	21.9	22.6	16.1
Contracts	27.1	30.9	32.6	28.4	28.5	25.8
Bursaries	18.0	20.4	23.3	23.5	28.7	29.9
TOTAL	411.2	472.2	525.6	521.8	537.5	39.4

Source: Statistics Canada

The goal of the government's policies and priorities in recent years has been to reinforce the integration of the university research system with the industrial research system in order to direct research and education towards the needs of industry.

Thus, the government developed a strategy that partly links the level of public assistance to university research to the level of financial support received from industry. The three federal councils that fund university research have been receiving constant budgets since 1987, but with the possibility of receiving extra resources in proportion to the

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amount allocated by the private sector. This "twinning of funds," which ends in 1991, should allow the three funding councils to distribute a maximum of $369 million per year.

RESEARCH AND DEVELOPMENT IN THE UNIVERSITIES

In universities, R&D is closely linked to the training of post-graduate students and is an important responsibility of most university professors. Some institutions, investments and university staff members are exclusively devoted to R&D; however, R&D is generally inextricably linked to teaching. Because of this, it is impossible to draw up a list of all the R&D activities in this sector. Statistics Canada produces data by using a model based on estimates of time spent on this activity by university staff.

The combined R&D expenditures of all Canadian universities are expected total $9.9 billion for 1988, a 92% increase from 1980 or 23% in real terms.

Financially (see Table A.8 in Appendix), universities subsidize a good portion of their own R&D needs (39% of total expenditures compared with 48% in 1980). The amount allocated by the federal government (grants, contributions and research fellowships) rose from 29% to 34% between 1980 and 1987. This increase can be attributed in part to the drop in funding from the university sector itself. Canadian universities also receive unallocated funds, in accordance with federal-provincial funding agreements on post-secondary education. Part of these funds could go towards research, but they are not included in the figures in the table.

More and more, business is funding research work in institutions of higher learning. This funding increased by 133% in nominal terms, or 61% in real terms, between 1980 and 1987. Despite this strong increase, business currently funds no more than 4% of all university research expenditures.

This leads us to ask if basic research results in a given scientific field can be easily transferred from one economic sector to

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another. There still seems to be a large gap between industry and universities. Are the results of university research of interest to industry, and can industry use the work carried out by universities?

COMMENTS ON THE FEDERAL INNOVATION POLICY

The basic objective of innovation policies should be to reinforce R&D activities in order to improve the country's competitiveness and to foster the general well-being of the population. In this respect, government intervention can be justified at certain levels:

- Where the government is the only or main regulatory body, as in defence, it is normal for it to make and encourage others to make technological advances in the interest of the community. However, this does not mean that the government alone should carry the burden of activities in these fields. It could also, and it does, involve other sectors by contracting out or buying research results.
- If, because of related high costs and uncertainties, private laboratories are unable or unwilling to carry out research, the government should try to fill in some of the gaps and remedy, at least to some extent, the market's inefficiency. It could also use various direct and indirect assistance measures to stimulate the other sectors in order to compensate for R&D under-investment.
- Since business invests less than the optimal social level in basic research, the results of which cannot be predicted, the government strongly supports this kind of research. Once again, there is the possibility of transferring some of the R&D work to another executing agency, generally universities.

Thus, even though government intervention is necessary, we cannot expect the government to be the sole source of assistance in some scientific and technological fields. We are trying to establish the appropriate level of federal intervention in R&D activities and the role to be played by other sectors.

For both historical and political reasons, the federal government participates in almost every level of the innovation process.

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Through federal laboratories, funding of university research, administering various programs to encourage technological development by industry, and its purchasing policy, the government has a major role in the scientific and technological field.

Government innovation priorities have developed significantly over the last few years. Federal support has been redirected towards industrial research at the expense of other fields such as the environment, energy and health. Long-term research has been redirected towards areas that are likely to contribute the most to technological advances, and cooperation between universities and industry has been encouraged for the same purpose. Thus, support for industrial research has been emphasized at the expense of R&D in government research facilities and universities.

By transferring a portion of the amount allocated for its own R&D activities to industry, the government would solve the notorious shortage of industrial R&D resources. Some explain under-investment in industrial research as a result of the relatively important position attained by government research over the years, which has not encouraged private-sector industry to carry out R&D work. In other words, industry has come to depend on government assistance; since the objective of most government programs is to fund the R&D costs of industry, which only agrees to carry out R&D work if the government shares the associated expenses and risks.

The rapid development of government measures to encourage industrial innovation in the last few years, coupled with increased efforts in the areas of regional development and small business, has produced a complex set of assistance measures and incentives that sometimes lacks real coherence and effectiveness. We have also seen efforts to expand the technological and scientific dimension of regional development policies. The main problem with this approach is the potential conflict between the needs of the regions and the national interests and effectiveness.

Finally, stronger interest in industry has led to a drop in funding for research carried out in universities and federal scientific facilities. Combined with the budget cuts that have seen intra-mural departmental spending slashed, it has brought about a decrease in basic

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research and led to the lively debate that is still being waged. Because the development of new technologies depends on continued scientific programs and the expansion of knowledge, ought not basic research assume its rightful place? The characteristic feature of basic research is that, through innovation, the benefits it produces do not accrue to the executing agency alone. Basic research normally requires only a small investment; however, it entails considerable risks. Moreover, it is not, as a rule, carried out to respond to market needs. For this reason, some of the intra-mural R&D work carried out by federal departments and laboratories and universities should be coordinated with the industrial sector.

CONCLUSION

This study shows that the federal government acts in various ways in a number of sectors to encourage innovation and that the industrial and university sectors play an important role in research and development. A high level of fruitful technological innovation largely depends on coordinated action by government, industry and the post-secondary education sector. However, differences in attitude towards the respective roles of R&D-funding and R&D-executing make it difficult to determine the optimal level of commitment for each sector. The effort first made by the federal government in 1987 to obtain the views of various science and technology advisory committees should continue and be stepped up. A coordinated strategy and rationalized allocation of R&D would make it possible to increase innovation in Canada and at the same time make the country more competitive.

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APPENDIX

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TABLE A.1
TOTAL EXPENDITURES ON R&D (GERD) BY PERFORMING SECTOR, 1979-1988

	Federal Government		Provincial Governments		Higher Education		Business Enterprise		Private non-profit Organizations		GERD	
	Current $	$ 1981	Current $	$ 1981	Current $	$ 1981	Current $	$ 1981	Current $	$ 1981	Current $	$ 1981
	millions of dollars											
1979	682	836	113	138	846	1,037	1,266	1,551	30	37	2,937	3,599
1980	776	860	139	154	984	1,091	1,571	1,742	35	39	3,505	3,886
1981	905	905	161	161	1,098	1,098	2,125	2,125	43	43	4,332	4,332
1982	1,088	1,001	195	179	1,269	1,167	2,489	2,290	49	45	5,090	4,683
1983	1,217	1,067	200	175	1,350	1,183	2,585	2,266	60	53	5,412	4,743
1984	1,387	1,175	205	174	1,432	1,214	2,994	2,537	71	60	6,089	5,160
1985	1,371	1,127	212	174	1,527	1,255	3,619	2,974	78	64	6,807	5,593
1986	1,417	1,131	215	172	1,637	1,306	3,828	3,055	88	70	7,185	5,734
1987 (1)	1,398	1,067	219	167	1,761	1,344	4,158	3,174	95	73	7,631	5,825
1988 (1)	1,320	978	228	169	1,893	1,403	4,427	3,282	102	76	7,970	5,906
	year-over-year percent change											
1979	-	-	-	-	-	-	-	-	-	-	-	-
1980	13.8	2.9	23.0	11.3	16.3	5.2	24.1	12.3	16.7	5.5	19.3	8.0
1981	16.6	5.2	15.8	4.5	11.6	0.7	35.3	22.0	22.9	10.8	23.6	11.5
1982	20.2	10.6	21.1	11.4	15.6	6.3	17.1	7.8	14.0	4.8	17.5	8.1
1983	11.9	6.6	2.6	-2.3	6.4	1.3	3.9	-1.1	22.4	16.7	6.3	1.3
1984	14.0	10.2	2.5	-0.9	6.1	2.6	15.8	12.0	18.3	14.4	12.5	8.8
1985	-1.2	-4.2	3.4	0.3	6.6	3.4	20.9	17.2	9.9	6.5	11.8	8.4
1986	3.4	0.4	1.4	-1.5	7.2	4.1	5.8	2.7	12.8	9.6	5.6	2.5
1987 (1)	-1.3	-5.6	1.9	-2.6	7.6	2.9	8.6	3.9	8.0	3.3	6.2	1.6
1988 (1)	-5.6	-8.4	4.1	1.1	7.5	4.4	6.5	3.4	7.4	4.8	4.4	1.4
	percent of GERD											
1979	23		4		29		43		1		100	
1980	22		4		28		45		1		100	
1981	21		4		25		49		1		100	
1982	21		4		25		49		1		100	
1983	22		4		25		48		1		100	
1984	23		3		24		49		1		100	
1985	20		3		22		53		1		100	
1986	20		3		23		53		1		100	
1987 (1)	18		3		23		54		1		100	
1988 (1)	17		3		24		56		1		100	

1) Preliminary.
Source : Statistics Canada.

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TABLE A.2
TOTAL EXPENDITURES ON R&D (GERD) BY FUNDING SECTOR, 1979-1988

	Federal Government		Provincial Governments		Higher Education		Business Enterprise		Private non-profit Organizations		Foreign		GERD	
	Current $	$ 1981	Current $	$ 1981	Current $	$ 1981	Current $	$ 1981	Current $	$ 1981	Current $	$ 1981	Current $	$ 1981
	millions of dollars													
1979	1,029	1,261	212	260	417	511	1,088	1,333	100	123	82	100	2,928	3,588
1980	1,183	1,312	252	279	471	522	1,379	1,529	109	121	100	111	3,494	3,874
1981	1,465	1,465	307	307	478	478	1,819	1,819	128	128	137	137	4,334	4,334
1982	1,766	1,625	376	346	587	540	2,020	1,858	130	120	211	194	5,090	4,683
1983	1,983	1,738	392	344	567	497	2,091	1,833	153	134	230	202	5,416	4,747
1984	2,275	1,928	411	348	550	466	2,431	2,060	168	142	256	217	6,091	5,162
1985	2,289	1,881	431	354	594	488	2,721	2,236	200	164	295	242	6,530	5,366
1986 (1)	2,369	1,891	444	354	637	508	2,831	2,259	211	168	309	247	6,801	5,428
1987 (1)	2,385	1,821	475	363	680	519	2,980	2,275	224	171	328	250	7,072	5,398
	year-over-year percent change													
1979	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1980	15.0	4.0	18.9	7.5	12.9	2.2	26.7	14.7	9.0	-1.4	22.0	10.3	19.3	8.0
1981	23.8	11.7	21.8	9.9	1.5	-8.5	31.9	19.0	17.4	5.9	37.0	23.6	24.0	11.9
1982	20.5	10.9	22.5	12.7	22.8	13.0	11.1	2.2	1.6	-6.6	54.0	41.7	17.4	8.0
1983	12.3	7.0	4.3	-0.7	-3.4	-8.0	3.5	-1.4	17.7	12.1	9.0	3.8	6.4	1.4
1984	14.7	10.9	4.8	1.4	-3.0	-6.2	16.3	12.4	9.8	6.2	11.3	7.6	12.5	8.7
1985	0.6	-2.4	4.9	1.7	8.0	4.7	11.9	8.5	19.0	15.4	15.2	11.7	7.2	3.9
1986 (1)	3.5	0.5	3.0	0.1	7.2	4.2	4.0	1.1	5.5	2.5	4.7	1.7	4.2	1.2
1987 (1)	0.7	-3.7	7.0	2.3	6.8	2.1	5.3	0.7	6.2	1.5	6.1	1.5	4.0	-0.5
	percent of GERD													
1979	35		7		14		37		3		3		100	
1980	34		7		13		39		3		3		100	
1981	34		7		11		42		3		3		100	
1982	35		7		12		40		3		4		100	
1983	37		7		10		39		3		4		100	
1984	37		7		9		40		3		4		100	
1985	35		7		9		42		3		5		100	
1986 (1)	35		7		9		42		3		5		100	
1987 (1)	34		7		10		42		3		5		100	

1) Preliminary.
Source : Statistics Canada.

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TABLE A.3
FEDERAL EXPENDITURES ON RESEARCH AND DEVELOPMENT BY DEPARTMENT, 1984-1989
(In millions of dollars)

Department	1984	1985	1986	1987	1988	1989
Intramural expenditures						
Agriculture	274	320	342	344	335	346
Atomic Energy	113	124	117	131	108	79
Energy, Mines and Resources	144	171	197	187	183	98
Environment	56	51	48	54	57	59
Fisheries and Oceans	121	135	138	121	117	125
Defence	110	124	122	128	139	142
National Research Council	238	287	232	275	271	275
Other	168	183	181	176	188	196
Total, Intramural expenditures	1,224	1,395	1,377	1,416	1,398	1,320
Extramural expenditures						
Agriculture	39	28	25	28	23	23
Atomic Energy	8	8	6	20	18	16
Energy, Mines and Resources	52	56	66	77	67	77
Environment	11	9	11	11	12	12
Fisheries and Oceans	6	4	5	7	7	6
Defence	49	68	88	93	98	126
National Research Council	123	148	146	140	162	152
Other	705	783	797	941	951	989
Total, extramural expenditures	989	1,100	1,142	1,184	1,213	1,401
Total expenditures on R&D						
Agriculture	313	348	367	372	358	369
Atomic Energy	121	132	123	151	126	95
Energy, Mines and Resources	196	227	263	264	250	175
Environment	67	60	59	65	69	71
Fisheries and Oceans	127	139	143	128	124	131
Defence	159	192	210	221	237	268
National Research Council	361	435	378	415	433	427
Other	873	966	978	1,117	1,139	1,185
TOTAL	2,213	2,495	2,519	2,600	2,611	2,721

Source : Statistics Canada.

TABLEAU A.4

AREAS OF APPLICATIONS OF R&D IN NATURAL SCIENCES AND ENGINEERING

	1984	1985	1986	1987	1988P	1989P
Advancement of science	14	14	15	14	15	15
Agriculture	11	13	13	12	12	12
Communications	4	3	3	3	3	3
Energy	15	14	12	12	10	7
Environment	4	2	2	2	2	2
Fisheries	3	3	4	3	3	3
Health	9	9	9	9	9	9
Industrial support	11	13	14	15	15	19
Natural resources	7	6	6	8	7	5
Oceans	3	3	3	2	1	2
Security	8	9	9	9	10	11
Space technology	2	3	2	2	2	2
Transportation	4	3	3	2	2	2
Other	5	5	5	7	9	8

Source : Statistics Canada.

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TABLE A.5
FEDERAL EXPENDITURES ON RESEARCH AND DEVELOPMENT BY PERFORMER, 1980-1989 (1)

Performing Sector	1981	1982	1983	1984	1985	1986	1987	1988P	1989P
	millions of dollars								
Intramural	780	912	1,094	1,218	1,389	1,372	1,416	1,398	1,320
Extramural	608	767	846	995	1,106	1,131	1,162	1,194	1,381
Industries	218	287	320	380	421	468	479	481	622
Universities	285	347	411	470	523	521	535	558	586
Non-profit organizations	15	11	11	24	21	18	17	19	20
Provincial and municipal administrations	34	37	4	4	15	11	21	23	22
Other in Canada	7	18	17	23	22	24	20	20	17
Foreign	49	67	83	94	104	89	90	93	114
Total	1,388	1,679	1,939	2,213	2,495	2,519	2,600	2,611	2,721
	per cent of share by performer								
Intramural	56	54	56	55	56	54	54	54	49
Extramural	44	46	44	45	44	45	45	46	51
Industries	16	17	17	17	17	19	18	18	23
Universities	21	21	21	21	21	21	21	21	22
Non-profit organizations	1	1	1	1	1	1	1	1	1
Provincial and municipal administrations	2	2	0	0	1	0	1	1	1
Other in Canada	1	1	1	1	1	1	1	1	1
Foreign	4	4	4	4	4	4	3	4	4
Total	100	100	100	100	100	100	100	100	100
	year-over-year per cent change								
Intramural	-	16.9	20.0	11.3	14.0	-1.2	3.2	-1.3	-5.6
Extramural	-	26.2	10.3	17.6	11.2	2.3	2.7	2.8	15.7
Industries	-	31.7	11.5	18.8	10.8	11.2	2.4	0.4	29.3
Universities	-	21.8	18.4	14.4	11.3	-0.4	2.7	4.3	5.0
Non-profit organizations	-	-26.7	0.0	118.2	-12.5	-14.3	-5.6	11.8	5.3
Provincial and municipal administrations	-	8.8	-89.2	0.0	275.0	-26.7	90.9	9.5	-4.3
Other in Canada	-	157.1	-5.6	35.3	-4.3	9.1	-16.7	0.0	-15.0
Foreign	-	36.7	23.9	13.3	10.6	-14.4	1.1	3.3	22.6
Total	-	21.0	15.5	14.1	12.7	1.0	3.2	0.4	4.2

P : Preliminary.
1) Beginning in 1983-84, figures are provided on a revised basis.
Source : Statistics Canada.

TABLE A.6

FEDERAL EXPENDITURES ON R&D IN THE INDUSTRY SECTOR (1)
(In millions of dollars)

Department	1983	1984	1985	1986	1987	1988	1989
Communications	14.9	13.1	15.4	15.0	2.6	2.6	3.2
Energy, Mines and Resources	21.9	35.6	36.1	44.1	40.5	27.4	27.4
Energy Atomic Canada	6.4	4.7	5.2	2.9	17.4	16.2	13.9
Environment	13.3	5.7	5.2	6.4	6.9	7.3	7.6
Fisheries and Oceans	3.6	5.8	4.4	7.2	4.4	4.3	4.3
Defence	38.9	37.9	53.0	71.0	80.5	81.1	112.0
NRC	72.3	81.0	96.5	103.8	97.8	120.1	111.3
Supply and Services	10.1	10.2	10.3	10.8	13.3	16.9	16.8
Transports	11.9	20.3	19.8	18.1	15.2	15.5	16.8
Regional Industrial Expansion	105.9	136.4	147.0	163.0	161.9	141.5	253.5
Other	20.2	29.1	28.8	25.5	39.3	47.4	55.0
TOTAL	319.4	379.8	421.7	467.8	479.8	480.3	621.8

Source : Statistics Canada, Federal Scientific Activities 1987-1988.

1) Fiscal year ending March 31.

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TABLE A.7
SOURCES OF FUNDS FOR INTRAMURAL RESEARCH AND DEVELOPMENT IN INDUSTRY, 1986

Industries	Canadian performing company	Federal government	Other Canadian sources	Foreign sources	Total
	in millions of dollars				
Mining, quarrying and oil wells					
Mining	39	-	3	-	49
Crude petroleum and natural gas	15	-	21	-	37
Total, mining, quarrying and oil wells	54	-	24	-	86
Manufacturing					
Food	79	5	3	1	88
Rubber and plastic	17	1	-	-	20
Textiles	33	1	-	1	36
Wood	4	9	-	-	22
Paper and allied	63	3	-	-	87
Primary metals	27	-	-	-	27
Semi-transformed metal products	30	1	-	-	88
Metal fabricating	26	4	-	-	33
Machinery	69	5	12	1	86
Aircraft and aircraft parts	217	125	8	18	368
Other transportation equipment	92	5	-	-	111
Telecommunication	328	6	-	-	621
Electronic products	24	4	-	-	30
Other electronic products	187	63	19	21	290
Office machines	100	8	5	115	228
Other electric products	56	9	3	5	72
Non-metallic mineral products	13	1	1	-	16
REfined petroleum and coal products	140	-	5	-	147
Pharmaceutical and medecine products	84	2	1	16	103
Other chemical products	145	5	8	4	162
Scientific and professional equipment	41	3	4	1	50
Other manufacturing industries	31	4	5	-	40
Total, manufacturing	1,805	266	214	439	2,724
Services					
Transportation and related services	131	6	-	-	142
Electric utility	134	35	-	-	180
Computer related services	115	17	65	2	198
Scientific and engineering	106	60	108	39	313
Other	118	17	19	31	185
Total, services	604	135	202	76	1,018
Total, industrial aggregate	2,464	409	440	515	3,828

Source : Statistics Canada.

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TABLE A.8
SOURCE OF FUNDS FOR R&D PERFORMED IN THE HIGHER EDUCATION SECTOR, 1978-1987 (1)

	Federal Government		Provincial Governments		Higher Education		Business Enterprise (2)		Private non-profit Organizations		Foreign		TOTAL	
	Current $	$ 1981	Current $	$ 1981	Current $	$ 1981	Current $	$ 1981	Current $	$ 1981	Current $	$ 1981	Current $	$ 1981
	millions of dollars													
1978	189	255	58	78	252	340	19	26	70	94	6	8	594	801
1979	211	259	60	74	276	338	22	27	77	94	7	9	653	800
1980	278	308	96	106	471	522	30	33	91	101	8	9	974	1,080
1981	353	353	115	115	478	478	34	34	104	104	10	10	1,094	1,094
1982	393	362	142	131	587	540	29	27	101	93	10	9	1,262	1,161
1983	457	401	153	134	567	497	32	28	121	106	11	10	1,341	1,175
1984	517	438	169	143	550	466	45	38	133	113	11	9	1,425	1,208
1985	516	424	181	149	594	488	60	49	162	133	9	7	1,522	1,251
1986 (3)	554	442	191	152	637	508	64	51	174	139	9	7	1,629	1,300
1987 (3)	592	452	205	156	680	519	70	53	186	142	10	8	1,743	1,331
	year-over-year percent change													
1978	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1979	11.6	1.6	3.4	-5.1	9.5	-0.6	15.8	3.8	10.0	0.0	16.7	12.5	9.9	-0.1
1980	31.8	19.2	60.0	44.7	70.7	54.4	36.4	23.4	18.2	6.9	14.3	3.4	49.2	34.9
1981	27.0	14.5	19.8	8.1	1.5	-8.5	13.3	2.2	14.3	3.1	25.0	12.8	12.3	1.3
1982	11.3	2.4	23.5	13.6	22.8	13.0	-14.7	-21.5	-2.9	-10.7	0.0	-8.0	15.4	6.1
1983	16.3	10.8	7.7	2.6	-3.4	-8.0	10.3	5.1	19.8	14.1	10.0	4.8	6.3	1.2
1984	13.1	9.4	10.5	6.8	-3.0	-6.2	40.6	36.0	9.9	6.3	0.0	-3.3	6.3	2.8
1985	-0.2	-3.2	7.1	3.8	8.0	4.7	33.3	29.3	21.8	18.1	-18.2	-20.7	6.8	3.6
1986 (3)	7.4	4.3	5.5	2.5	7.2	4.2	6.7	3.6	7.4	4.3	0.0	-2.9	7.0	4.0
1987 (3)	6.9	2.2	7.3	2.7	6.8	2.1	9.4	4.6	6.9	2.2	11.1	6.3	7.0	2.3
	percent of GERD													
1978	32		10		42		3		12		1		100	
1979	32		9		42		3		12		1		100	
1980	29		10		48		3		9		1		100	
1981	32		11		44		3		10		1		100	
1982	31		11		47		2		8		1		100	
1983	34		11		42		2		9		1		100	
1984	36		12		39		3		9		1		100	
1985	34		12		39		4		11		1		100	
1986 (3)	34		12		39		4		11		1		100	
1987 (3)	34		12		39		4		11		1		100	

1) Beginning in 1980, a revised estimation procedure was employed.
2) Natural Sciences and Engineering only.
3) Preliminary.